IN THE CLAIMS

What is claimed is:

1. A method for making a semiconductor device comprising:

forming on a substrate a high-k gate dielectric layer;

removing impurities from the high-k gate dielectric layer, and increasing the oxygen content of the high-k gate dielectric layer; and then

forming a gate electrode on the high-k gate dielectric layer.

2. The method of claim 1 wherein the high-k gate dielectric layer is formed by atomic layer chemical vapor deposition, and wherein the high-k gate dielectric layer comprises a material selected from the group consisting of hafnium oxide, hafnium silicon oxide, lanthanum oxide, zirconium oxide, zirconium silicon oxide, titanium oxide, tantalum oxide, barium strontium titanium oxide, barium titanium oxide, strontium titanium oxide, yttrium oxide, aluminum oxide, lead scandium tantalum oxide, and lead zinc niobate.

3. The method of claim 1 wherein a wet chemical treatment is applied to the high-k gate dielectric layer to remove impurities from that layer and to increase the oxygen content of that layer.

4. The method of claim 3 wherein the wet chemical treatment comprises exposing the high-k gate dielectric layer to a solution that comprises a source of hydroxide at a sufficient temperature for a sufficient time to remove impurities from the high-k gate dielectric layer and to increase the oxygen content of the high-k gate dielectric layer.

5. The method of claim 4 wherein the source of hydroxide is selected from the group consisting of deionized water, hydrogen peroxide, ammonium hydroxide, and a tetraalkyl ammonium hydroxide.

6. The method of claim 5 wherein the source of hydroxide is tetramethyl ammonium hydroxide.

7. The method of claim 6 wherein the gate electrode comprises polysilicon.

8. A method for making a semiconductor device comprising:

forming on a substrate a high-k gate dielectric layer;

applying a wet chemical treatment to the high-k gate dielectric layer to remove impurities from the high-k gate dielectric layer, and to increase the oxygen content of the high-k gate dielectric layer; and then

forming a layer that comprises polysilicon on the high-k gate dielectric layer.

9. The method of claim 8 wherein the high-k gate dielectric layer is formed by atomic layer chemical vapor deposition, and is between about 5 angstroms and about 40 angstroms thick.

10. The method of claim 9 wherein the high-k gate dielectric layer comprises a material selected from the group consisting of hafnium oxide, zirconium oxide, titanium oxide, and aluminum oxide.

11. The method of claim 10 wherein the wet chemical treatment comprises exposing the high-k gate dielectric layer to a solution that comprises a source of hydroxide at a sufficient temperature for a sufficient time to remove chlorine from

the high-k gate dielectric layer and to increase the oxygen content of the high-k gate dielectric layer.

12. The method of claim 11 wherein the source of hydroxide is selected from the group consisting of deionized water, hydrogen peroxide, ammonium hydroxide, and a tetraalkyl ammonium hydroxide.

13. A method for making a semiconductor device comprising:

forming a high-k gate dielectric layer on a substrate, the high-k gate dielectric layer being less than about 60 angstroms thick and comprising a material selected from the group consisting of hafnium oxide, zirconium oxide, titanium oxide, and aluminum oxide;

exposing the high-k gate dielectric layer to a solution that comprises a source of hydroxide at a sufficient temperature for a sufficient time to remove chlorine from the high-k gate dielectric layer and to increase the oxygen content of the high-k gate dielectric layer;

forming a layer that comprises polysilicon on the high-k gate dielectric layer; and

etching the polysilicon containing layer and the high-k gate dielectric layer.

14. The method of claim 13 wherein the high-k gate dielectric layer is formed by atomic layer chemical vapor deposition and is between about 5 angstroms and about 40 angstroms thick.

15. The method of claim 14 wherein the source of hydroxide is selected from the group consisting of deionized water, hydrogen peroxide, ammonium hydroxide, and a tetraalkyl ammonium hydroxide.

16. The method of claim 15 wherein the high-k gate dielectric layer is exposed to a solution that comprises hydrogen peroxide at a temperature that is between about 15°C and about 40°C for at least about one minute.

17. The method of claim 15 wherein the high-k gate dielectric layer is exposed to a solution that comprises hydrogen peroxide and ammonium hydroxide at a temperature that is between about 15°C and about 40°C for at least about one minute.

18. The method of claim 15 wherein the high-k gate dielectric layer is exposed to a solution that comprises ammonium hydroxide at a temperature that is between about 15°C and about 90°C for at least about one minute.

19. The method of claim 15 wherein the high-k gate dielectric layer is exposed to a solution that comprises tetramethyl ammonium hydroxide at a temperature that is between about 15°C and about 90°C for at least about one minute.

20. The method of claim 15 wherein the high-k gate dielectric layer is exposed to a solution that comprises deionized water at a temperature of at least about 35°C for at least about one minute.

21. The method of claim 15 wherein the source of hydroxide acts as an oxidizer and wherein the oxygen content of the high-k gate dielectric layer is increased by at least about 10 percent, when the high-k gate dielectric layer is exposed to the solution that includes the source of hydroxide.

22. The method of claim 15 wherein the chlorine content of the high-k gate dielectric layer is decreased by at least about 80 percent, when the high-k gate dielectric layer is exposed to the solution that includes the source of hydroxide.

23. The method of claim 15 wherein the high-k gate dielectric layer is partially etched, when the high-k gate dielectric layer is exposed to the solution that includes the source of hydroxide.

24. The method of claim 15 wherein at least about 10% of the high-k gate dielectric layer is partially etched, when the high-k gate dielectric layer is exposed to the solution that includes the source of hydroxide.

25. The method of claim 15 wherein less than about 3 angstroms of oxide grows on the substrate, when the high-k gate dielectric layer is exposed to the solution that includes the source of hydroxide.

26. The method of claim 15 further comprising forming a second high-k gate dielectric layer, and exposing the second high-k gate dielectric layer to a second solution that includes a source of hydroxide, prior to forming the layer that comprises polysilicon.